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(54) **TUNABLE RF RETURN PATH FILTER WITH
AUTOMATIC CHANNEL PLAN DETECTION**

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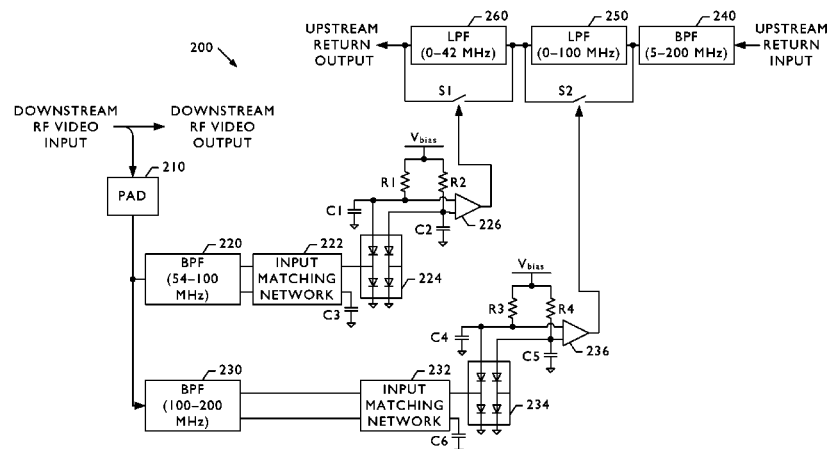
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(57) **ABSTRACT**

A method and computing device that provides a tunable RF filter for a two-way communication system. The method receives a downstream video signal, and filters the downstream video signal into at least one downstream bandwidth band, each downstream bandwidth band related to desired upstream/downstream bandwidth splits. The method performs an energy detection on each downstream bandwidth band, and determines a lowest frequency of said at least one downstream bandwidth band that contains downstream video content. The method sets a diplex filter upstream/downstream frequency cutoff to a maximum upstream bandwidth that does not conflict with the lowest frequency of said at least one downstream bandwidth band that contains downstream video content.

13 Claims, 3 Drawing Sheets



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FIG. 1

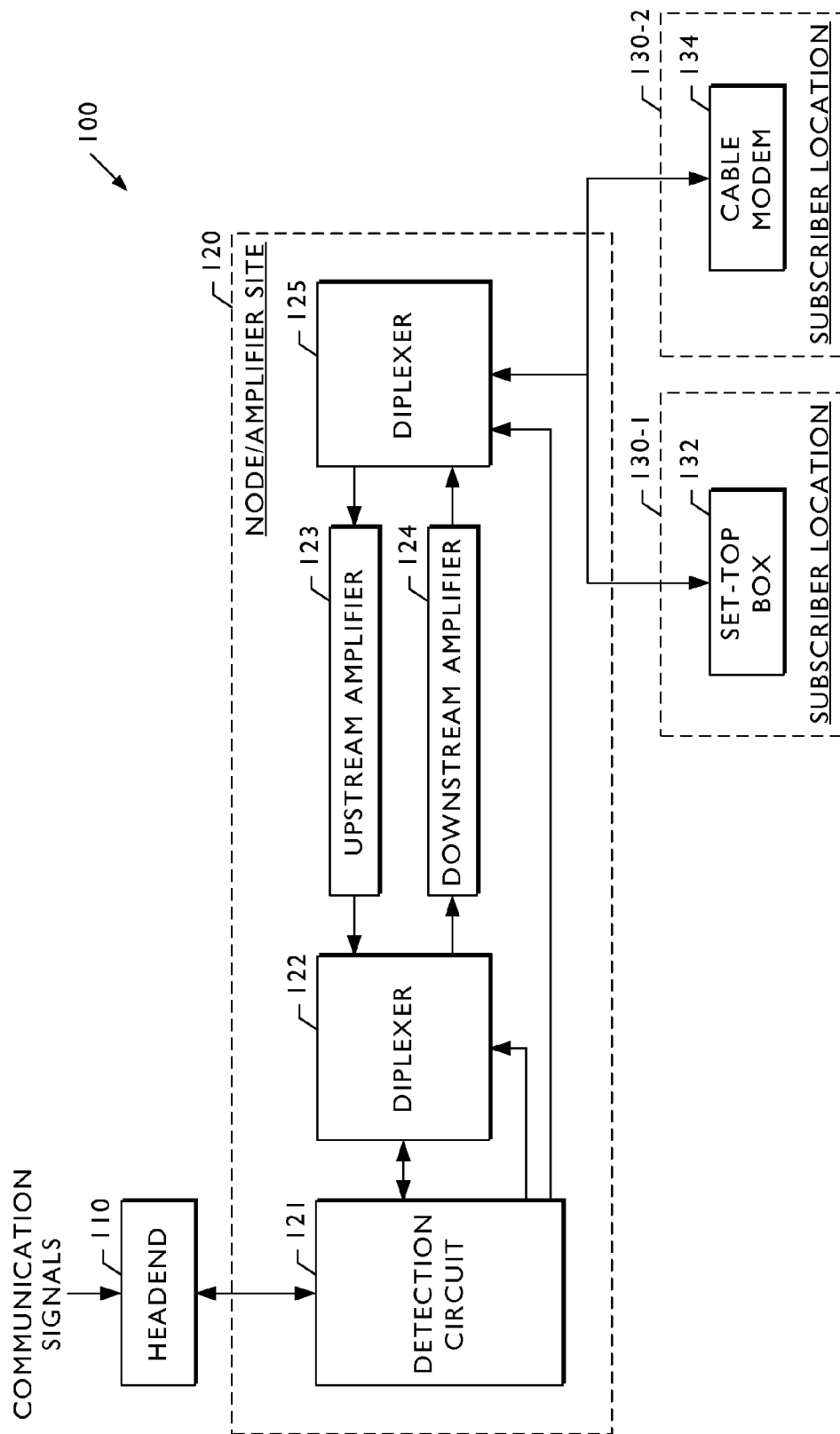


FIG. 2

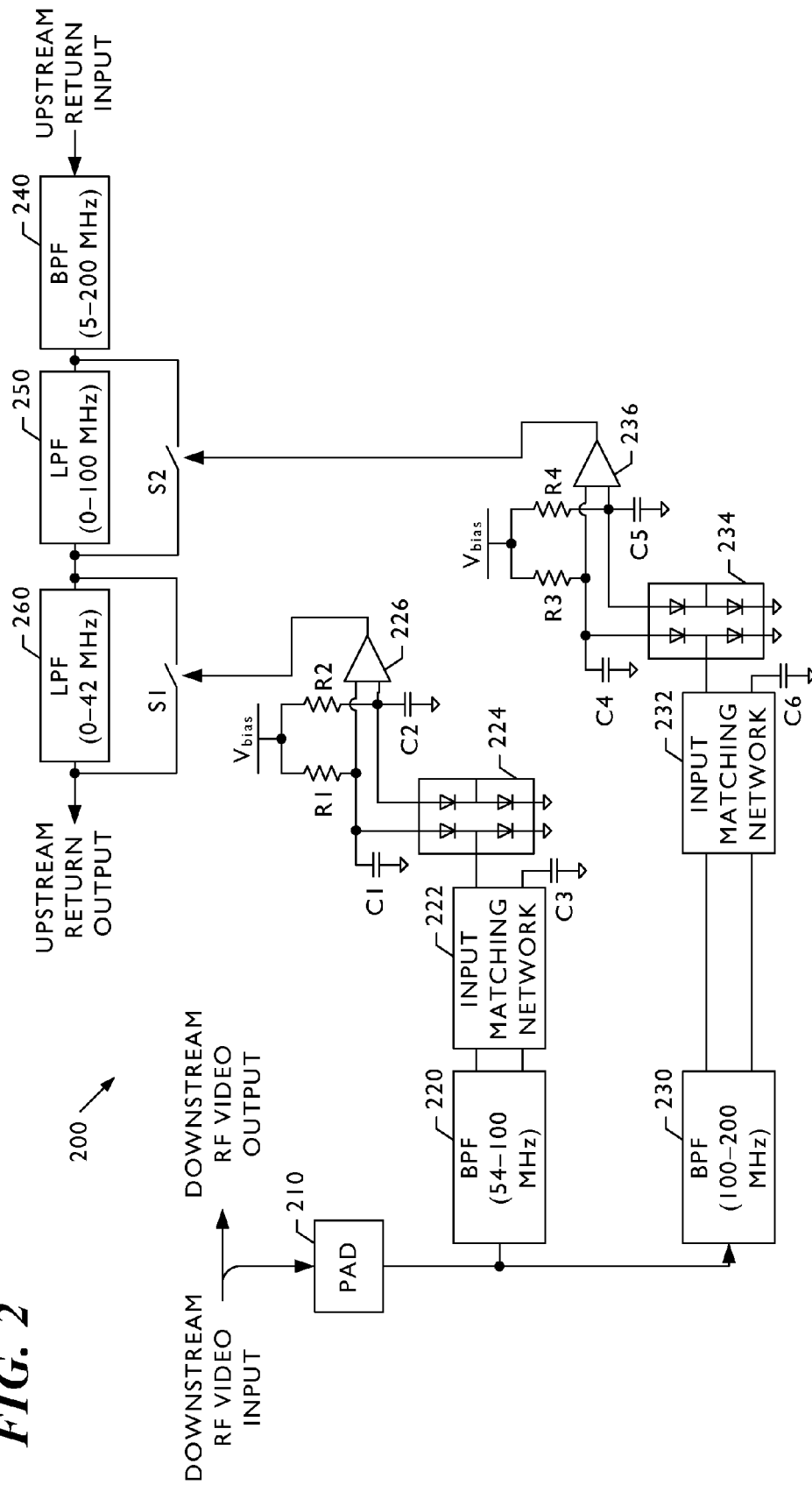
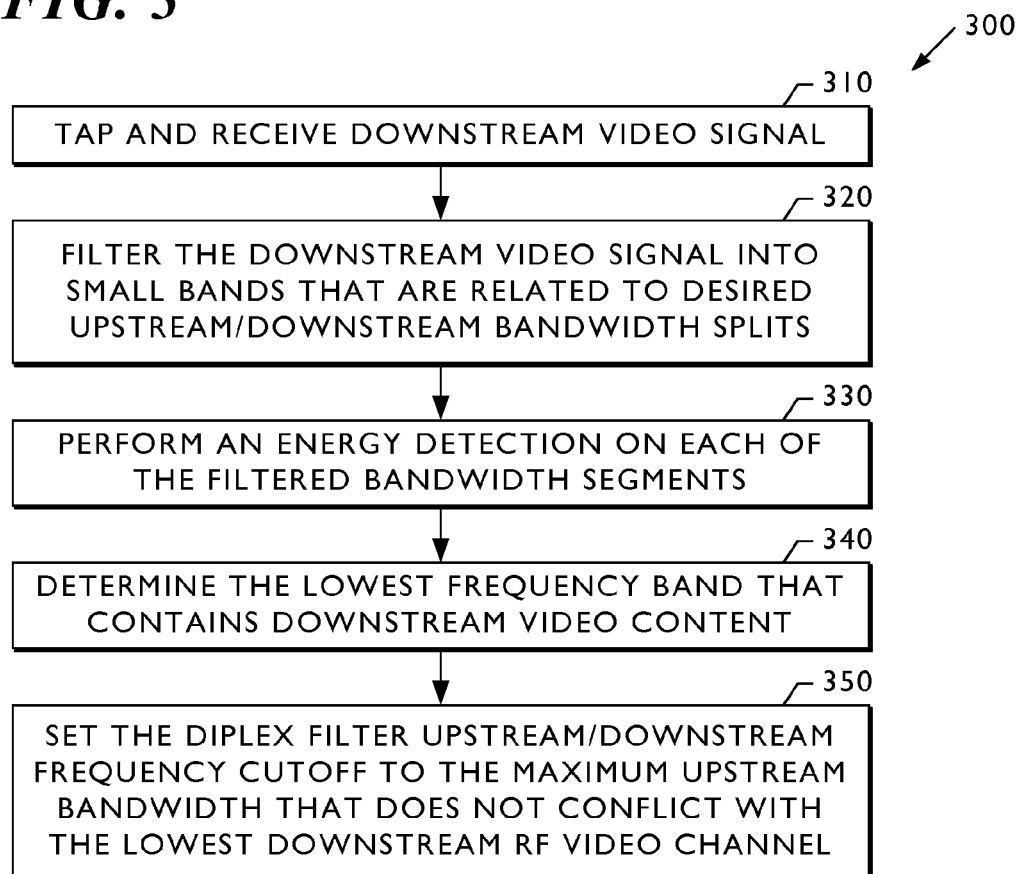


FIG. 3

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TUNABLE RF RETURN PATH FILTER WITH AUTOMATIC CHANNEL PLAN DETECTION

BACKGROUND

A hybrid fiber-coaxial (HFC) network is a broadband network that combines optical fiber and coaxial cable. The HFC network typically provides two-way communication between a cable operator's headend facility and a subscriber's location. The headend facility collects and processes communication signals, and distributes the signals to the subscriber's location using a downstream communication path. A set-top box or cable modem at the subscriber's location receives the communication signals on the downstream communication path, and transmits other communication signals to the headend facility using an upstream communication path.

The upstream communication signals allow the cable operators to offer advanced communication services to the subscribers. These advanced communication services include pay-per-view programming, video-on-demand services, telephony, interactive digital networks, and computer data services. The transmission of the upstream communication signals are in a frequency band that is either higher or lower than the downstream communication signals to avoid interference between the upstream and downstream communication signals. As these advanced communication services become more popular, the need for additional bandwidth on the upstream communication path is increasing.

The only way the cable operator can increase the bandwidth on the upstream communication path today is to send a technician to an amplifier site on the HFC line, or telephone pole, and replace the analog filter sub-assemblies in the amplifier. The cable operator needs a way to build an HFC plant today that will allow them to upgrade the bandwidth of the upstream channels in the future without the need to send a technician to replace previously installed equipment.

There is a need for a method of detecting the allocation of the downstream communication path to determine the correct bandwidth of the upstream communication path. The presently disclosed invention satisfies this demand.

SUMMARY

Aspects of the present invention provide a method and computing device that provides a tunable RF filter for a two-way communication system. The method receives a downstream video signal, and filters the downstream video signal into at least one downstream bandwidth band, each downstream bandwidth band related to desired upstream/downstream bandwidth splits. The method performs an energy detection on each downstream bandwidth band, and determines a lowest frequency of said at least one downstream bandwidth band that contains downstream video content. The method sets a diplex filter upstream/downstream frequency cutoff to a maximum upstream bandwidth that does not conflict with the lowest frequency of said at least one downstream bandwidth band that contains downstream video content.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram that illustrates one embodiment of the hardware components of a system that performs the present invention.

FIG. 2 is a schematic diagram that illustrates a tunable RF return path filter according to one embodiment of the present invention.

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FIG. 3 is a flow diagram that illustrates a method of adjusting the bandwidth of the upstream communication in an HFC plant according to one embodiment of the present invention.

DETAILED DESCRIPTION

FIG. 1 is a block diagram that illustrates one embodiment of the hardware components of a system that performs the present invention. A hybrid fiber-coaxial (HFC) network 100 is a two-way broadband network that includes a headend 110, node/amplifier site 120, and subscriber location 130. In another embodiment, the HFC network 100 may include any number of headend 110 and node/amplifier site 120 components to provide load balancing and redundancy to support two-way communication with any number of subscriber locations 130.

As shown in FIG. 1, the headend 110 receives communication signals from an external source, and distributes those communication signals, via the node/amplifier site 120, to the subscriber location 130 using downstream channels. The subscriber location 130 includes a device, such as a set-top box 132 or cable modem 134, to receive radio frequency (RF) communication signals on the downstream channels, and transmit other communication signals on the upstream channels. The other communication signals utilize the upstream channels and allow the subscriber to take advantage of advanced communication services from the cable operator. The node/amplifier site 120 includes a detection circuit 121, first diplexer 122, upstream amplifier 123, downstream amplifier 124, and second diplexer 125. The upstream amplifier 123 boosts the signal levels for the upstream channels, and the downstream amplifier 124 boosts the signal levels for the downstream channels to overcome the loss imposed by the coaxial cables, and splitters and combiners. The detection circuit 121 performs the disclosed method of the present invention.

FIG. 2 is a schematic diagram that illustrates a tunable RF return path filter according to one embodiment of the present invention. The tunable RF return path filter, shown in FIG. 2, illustrates one embodiment of the implementation of the detection circuit 121 shown in FIG. 1.

The circuit 200 shown in FIG. 2 includes a downstream RF video input for receiving downstream RF video from the headend 110. The circuit 200 functions as a pass-thru device for the downstream communication path by sending the downstream RF video to the set-top box 132, or cable modem 134, via a downstream RF video output.

The circuit 200 includes a directional tap of the downstream communication path to create a downstream RF video signal for the circuit 200. This downstream RF video signal is input to an RF attenuator pad 210 to lower the amplitude of the signal for a series of band pass filters (BPFs) and RF energy detectors. The RF energy detectors monitor the low-frequency bands of the downstream RF video signal, and control switches that bypass or enable the filtering of the upstream RF communication signal at available upstream bandwidth ranges. This allows the circuit 200 to adjust the upstream bandwidth to have a high-frequency roll-off that is slightly less than the lowest frequency in use on the downstream RF video signal. In various embodiments, the RF attenuator pad 210 connects to any number of BPFs and RF energy detectors, where the number of BPFs depends upon the granularity of the RF energy detectors desired by the cable operator.

As shown in FIG. 2, the first BPF 220 filters the RF video signal in a desired range (e.g., 54-100 MHz), and the second BPF 230 filters the RF video signal in another desired range

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(e.g., 100-200 MHz). The first BPF **220** connects to an RF energy detector circuit that includes an input matching network **222**, matched Schottky diodes **224**, capacitors **C1**, **C2**, **C3**, resistors **R1**, **R2**, and a differential amplifier **226**, where the output of the differential amplifier **226** connects to a switch **S1**. When the first BPF **220** detects RF energy in the desired range, the switch **S1** is closed, otherwise the switch **S1** is open. The second BPF **230** connects to an RF energy detector circuit that includes an input matching network **232**, matched Schottky diodes **234**, capacitors **C4**, **C5**, **C6**, resistors **R3**, **R4**, and a differential amplifier **236**, where the output of the differential amplifier **236** connects to a switch **S2**. When the second BPF **230** detects RF energy in the other desired range, the switch **S2** is closed, otherwise the switch **S2** is open. In various other embodiments, the RF energy detector circuit includes an expensive integrated circuit solution, and a low-cost matched Schottky diode solution that feeds to a comparator.

The circuit **200** also includes an upstream return input for receiving upstream RF communication signal from the set-top box **132**, or cable modem **134**. The upstream RF communication signal is an input to a BPF **240**, and a series of switched low-pass filters (LPFs). The BPF **240** filters the upstream RF communication signal in a desired range (e.g., 5-200 MHz). A switch **S2** controls whether the upstream RF communication signal bypasses or enables a first low-pass filter (LPF) **250** that further filters the upstream RF communication signal to a desired sub-range (e.g., 0-100 MHz). The switch **S2**, and whether the upstream RF communication signal bypasses or enables the first LPF **250**, is controlled by the output of the differential amplifier **236** of one of the RF energy detector circuits that filters the downstream RF video signal. A switch **S1** controls whether the upstream RF communication signal bypasses a second LPF **260** that further filters the upstream RF communication signal to a desired sub-range (e.g., 0-42 MHz). The switch **S1**, and whether the upstream RF communication signal bypasses or enables the second LPF **260**, is controlled by the output of the differential amplifier **226** of one of the RF energy detector circuits that filters the downstream RF video signal. Each LPF **250**, **260** defines an available upstream bandwidth range, and the switches **S1**, **S2** allow the circuit **200** to either bypass or enable the first LPF **250** or second LPF **260**, thereby adjusting the overall bandwidth on the upstream RF communication signal.

FIG. 3 is a flow diagram that illustrates a method of adjusting the bandwidth of the upstream communication in an HFC plant according to one embodiment of the present invention. The process **300** shown in FIG. 3 begins when the circuit **200** taps and receives a downstream video signal (step **310**) that is processed by a number of filters into small bands that are related to desired upstream/downstream bandwidth segments (step **320**). Each filter receives the downstream video signal as an input and produces one of the bandwidth segments as an output. The process **300** performs an energy detection on each of the filtered bandwidth segments (step **330**) and determines the lowest frequency band that contains downstream video content (step **340**). The process **300** sets the diplex filter upstream/downstream frequency cutoff to the maximum upstream bandwidth that does not conflict with the lowest downstream RF video channel (step **350**).

Although the disclosed embodiments describe a fully functioning method and computing device that provides a tunable RF filter for a two-way communication system, the reader should understand that other equivalent embodiments exist. Since numerous modifications and variations will occur to those reviewing this disclosure, the method and computing

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device that provides a tunable RF filter for a two-way communication system is not limited to the exact construction and operation illustrated and disclosed. Accordingly, this disclosure intends all suitable modifications and equivalents to fall within the scope of the claims.

We claim:

1. A method, comprising:

in a detection circuit, receiving an attenuated downstream communication signal for controlling a plurality of switches;

using a plurality of bandpass filters to filter the attenuated downstream communication signal into a plurality of downstream bandwidth bands, each downstream bandwidth band related to a corresponding one of the plurality of switches and a corresponding available upstream/downstream bandwidth split;

performing an energy detection on each downstream bandwidth band for determining whether a frequency of said downstream bandwidth band contains downstream communication content; and

based on a result of the determining on each downstream bandwidth band, controlling the corresponding one of the plurality of switches to one of bypassing and enabling a corresponding low-pass filter of a diplex filter, such that the diplex filter is thereby configured to receive an upstream communication signal and to output a filtered upstream communication signal having a maximum upstream bandwidth that does not conflict with a lowest downstream frequency of said plurality of downstream bandwidth bands that contains downstream communication content.

2. The method of claim 1, wherein the receiving of the attenuated downstream communication signal further comprises:

obtaining a first downstream communication signal from a first output of a directional tap that receives the first downstream communication signal from a signal source,

the directional tap having a second output for passing the first downstream communication signal through to a downstream device.

3. The method of claim 1, wherein each downstream bandwidth band is a low frequency band of the downstream communication signal.

4. The method of claim 1, wherein each available upstream/downstream bandwidth split corresponds to at least one of said plurality of downstream bandwidth bands such that when the result of the determining is an indication of downstream communication content on the at least one corresponding downstream bandwidth band, a corresponding at least one low-pass filter of the diplex filter is enabled for adjusting the diplex filter to output the filtered upstream communication signal according to said upstream/downstream bandwidth split.

5. The method of claim 1, wherein each available upstream/downstream bandwidth split corresponds to a unique one of said plurality of downstream bandwidth bands such that when the result of the determining is an indication of downstream communication content on the unique one corresponding downstream bandwidth band, a corresponding unique one low-pass filter of the diplex filter is enabled for adjusting the diplex filter to output the filtered upstream communication signal according to said upstream/downstream bandwidth split.

6. The method of claim 1, wherein the energy detection on each downstream bandwidth band includes providing each

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downstream bandwidth band as an input to at least one of an integrated circuit, and a matched Schottky diode solution that feeds to a comparator.

7. A node device, comprising:

one or more diplexers resident in the node device; and
a detection circuit disposed in communication with the a plurality of switches, the detection circuit configured to: in the detection circuit, receive an attenuated downstream communication signal for controlling the plurality of switches;

using a plurality of bandpass filters to filter the attenuated downstream communication signal into a plurality of downstream bandwidth bands, each downstream bandwidth band related to a corresponding one of the plurality of switches and a corresponding upstream/downstream bandwidth split;

perform an energy detection on each downstream bandwidth band to determine whether a frequency of said downstream bandwidth band contains downstream communication content; and

based on a result of the determining on each downstream bandwidth band, control the corresponding one of the plurality of switches to one of bypassing and enabling a corresponding low-pass filter of a diplex filter, such that the diplex filter is thereby configured to receive an upstream communication signal and to output a filtered upstream communication signal having a maximum upstream bandwidth that does not conflict with a lowest downstream frequency of said plurality of downstream bandwidth bands that contains downstream communication content.

8. The node device of claim 7, wherein to receive the attenuated downstream communication signal, the detection circuit is further configured to:

obtain a first downstream communication signal from a first output of a directional tap that receives the first downstream communication signal from a signal source,

the directional tap having a second output configured to pass the first downstream communication signal through to a downstream device.

9. The node device of claim 7, wherein each downstream bandwidth band is a low frequency band of the downstream communication signal.

10. The node device of claim 7, wherein each upstream/downstream bandwidth split corresponds to at least one of said plurality of downstream bandwidth bands such that when the result of the determining is an indication of downstream communication content on the at least one corresponding downstream bandwidth band, a corresponding at least one low-pass filter of the diplex filter is enabled for adjusting the diplex filter to output the filtered upstream communication signal according to said upstream/downstream bandwidth split.

11. The node device of claim 7, wherein each upstream/downstream bandwidth split corresponds to a unique one of said plurality of downstream bandwidth bands such that when the result of the determining is an indication of downstream

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communication content on the unique one corresponding downstream bandwidth band, a corresponding unique one low-pass filter of the diplex filter is enabled for adjusting the diplex filter to output the filtered upstream communication signal according to said upstream/downstream bandwidth split.

12. The node device of claim 7, wherein the energy detection on each downstream bandwidth band includes providing each downstream bandwidth band as an input to at least one of an integrated circuit, and a matched Schottky diode solution that feeds to a comparator.

13. A node/amplifier apparatus for tunable return path filtering, the node/amplifier apparatus comprising:

one of a node device and an amplifier device, configured to be deployed in a hybrid fiber-coaxial (HFC) network in a site between a headend and one or more subscriber devices;

a downstream input configured for receiving a downstream communication signal from the headend;

a downstream output communicatively coupled to the downstream input, the downstream output configured for sending the downstream communication signal to the one or more subscriber devices;

an upstream input, configured for receiving an upstream communication signal from the one or more subscriber devices;

one or more diplexers, communicatively coupled to the upstream input and to an upstream output for sending a filtered upstream communication signal to the headend;

a detection circuit, communicatively coupled to the downstream input and disposed in communication with a plurality of switches, the detection circuit configured for:

receiving an attenuated downstream communication signal for controlling the plurality of switches;

using a plurality of bandpass filters to filter the attenuated downstream communication signal into a plurality of downstream bandwidth bands, each downstream bandwidth band related to a corresponding one of the plurality of switches and a corresponding available upstream/downstream bandwidth split;

performing an energy detection on each downstream bandwidth band for determining whether a frequency of said downstream bandwidth band contains downstream communication content; and

based on a result of the determining on each downstream bandwidth band, controlling the corresponding one of the plurality of switches to one of bypassing and enabling a corresponding low-pass filter of the one or more diplexers, such that the one or more diplexers are thereby configured for providing the filtered upstream communication signal to the upstream output, the filtered upstream communication signal having a maximum upstream bandwidth that does not conflict with a lowest downstream frequency of said plurality of downstream bandwidth bands that contains downstream communication content.

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